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# solplan review

the independent journal of energy conservation, building science & construction practice

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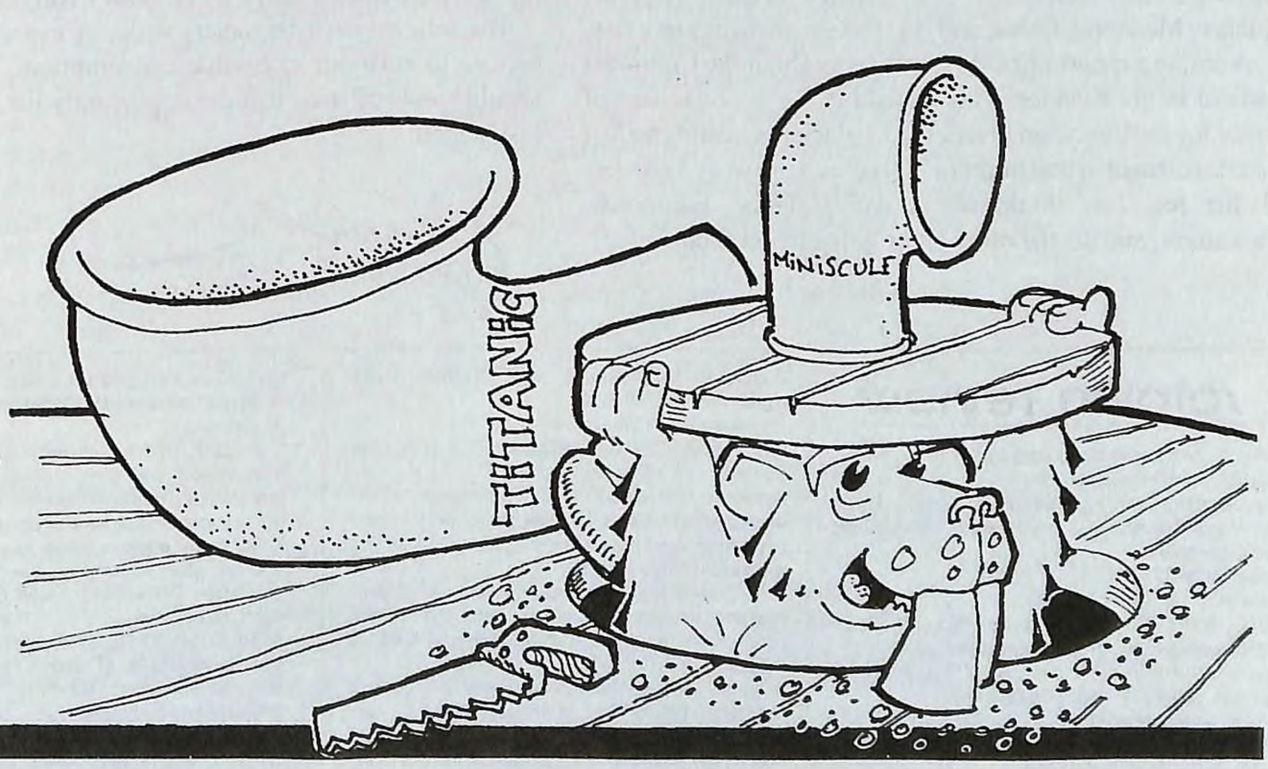

## From the Editor . . .

The lazy days of summer are fast fading into memory. All around us is evidence of Fall and Winter soon to come. At our cold northern latitudes we Canadians relish the sunny warm summers that seem far too short. Unless we are directly affected by forest fires or other hot dry weather phenomena, a dry hot summer is to be cherished.

Unfortunately, the evidence now coming in is that this year's hot summer, although it was affected by the el Nino phenomenon, was far hotter than any in the past. The nine hottest years on record have all occurred in the last twelve years! Those who track the data see a pattern that is proving global-warming theories, and global warming is happening much faster than expected.

Many of us are still in a state of denial that human activity could be the cause of global climate changes. After all, trying to ignore an issue is the easier way of dealing with it, and one way of not having to take difficult actions. Secretly many Canadians relish the prospect of a warmer climate. After all, few of us really enjoy the deep freeze of a typical Canadian winter.

However, the consequences of global warming are immense. Lower space heating bills are a trivial positive that is more than offset by the harmful negatives. Changes in the climate can mean more intense storms, be they tropical storms in the south or rain or snow in the north. In the last couple of years we have already seen floods "of the century" in Central Europe, Quebec, Manitoba, China, and Bangladesh, to name just a few.

A chilling report I heard recently was about the Columbia icefield in the Rockies. This icefield is the major source of water for the Canadian prairies. The glacier is melting so fast that it is estimated that in about 300 years there will be no more glacier ice. Just think, where will Calgary, Edmonton, Saskatoon, and all the other cities going to get their water?

It is easy to sit back and say - what can I as an individual do? The crisis we are getting into has been created by people only in the last two centuries. It is the result of individual actions that, as a whole, have had an incredible impact. One of the biggest actions is our ever growing use of energy - whether it is fuel for our toys (whether they are sport utility vehicles, power boats, or home electronics), the power tools we work with, or basic energy we need to survive in our harsh climate.

The building sector itself is responsible for about one third of all energy use in this country. We know that much improvement can be made to the building stock. The standards laid out in the Model National Energy Code are modest, and if implemented would improve energy performance by only a modest amount. Yet to deal with the real problem of global warming we should be building new and upgrading existing buildings to a standard no less than that of the R-2000 program (or C-2000 for commercial buildings). However, these are only voluntary programs, with at best modest impact.

Unless we as an industry become more aggressive at promoting and actually carrying out these resource and energy efficiency practices, they will be forced on us. As the environmentalists have been saying for some time, and now the scientists are telling us, the consequences of business-as-usual practices will be catastrophic for all life on earth! How much longer can we carry on without taking action?

The solution must be society wide, by every individual's actions to curb our excessive consumption. The solution should surely offer a business opportunity for those that do take action.

Richard Kadulski,
Editor

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# Code Ventilation Requirements

*The 1995 edition of the National Building Code of Canada has extensively changed the ventilation requirements for housing. The code includes detailed prescriptive requirements, because in the past ventilation system design and compliance has varied.*

*In this piece we are focusing on the new requirements in the National Building Code. These requirements apply in all areas except for Ontario and B.C. where provincial requirements were modified several years ago, and will be continued with only minor modifications.*

Ongoing cross Canada surveys of conventional, merchant builder houses have shown that houses are increasingly being built tighter. The trend to more airtight construction has been with us for the past 50 years or so through the introduction of new products and construction techniques. If today's houses relied only on leakage through the building envelope for fresh outdoor air, then 70% of them would have less than 0.3 air changes per hour (ACH) over the heating season, and 90% would have at least one month when the air change rate would be less than 0.3 ACH.

Houses normally do not need this much ventilation all the time, although it has been recognized that about 0.3 ACH for the average sized house is a suitable minimum level for health and comfort. If this rate cannot be achieved, most households will experience poor indoor air quality and high humidity levels at some times.

Traditionally, a significant portion of the air change in houses was due to air flow up the flue. However, with modern heating equipment the dynamics have changed. Electric heating eliminates the need for flues. High efficiency combustion furnaces reduce the air flow up a flue by more efficient combustion, by restricting flue air leakage between firing periods, and eliminating the need for open flues.

The increased use of such heating systems combined with increased emphasis on sealing the building envelope has led to a concern that the natural air change may be inadequate at times to provide a healthy environment. Condensation problems resulting from higher humidity levels within the dwelling are also a concern. That is why the Building Code has included requirements for mechanical ventilation for many years.

The purpose of ventilation is to maintain healthy indoor conditions for occupants. Ventilation for occupants must not be confused with ventilation requirements for the structure or combustion air requirements for combustion equipment, which is part of the heating system.

Changes to the ventilation requirements of the 1995 NBC were made because of concerns that the 1990 code ventilation requirements were inadequate, especially regarding distribution of outdoor air brought into the house and the prevention of the depressurization of the house, which can interfere with the venting of combustion appliances.

Essentially, every house must be provided with a mechanical system that complies with CSA Standard F326 "Residential Mechanical Ventilation Requirements." This is a comprehensive performance standard that offers flexibility for those experienced in ventilation system design. However, because it is a performance standard, it requires professional design to prove compliance. That is why home builders requested that prescriptive alternatives that meet the performance requirements be written into the code. As a result, Section 9.32 has been greatly expanded to offer prescriptive alternatives. The latest code changes provide a choice of "prescriptive" and "good practice" options for compliance with ventilation requirements.

### System Capacity

The ventilation system capacity is essentially related to the number of people in the house rather than to the volume of the house. Total system capacity is based on the number and types of rooms as noted in the table. For example, a three-bedroom house, with family room, recreation room, two bathrooms and basement requires a total ventilation capacity of 70 cfm.

Ventilation can be supplied by a single fan or a combination of fans, but clearly labelled controls must allow the airflow to be reduced to 50%. If the principal fan is controlled by a dehumidistat or other automatic control, a manual switch must be able to override the automatic control.

Exhaust fans must be coupled to an air intake such as a pipe from the exterior into the return air system of a forced air furnace to limit pressure unbalance in the house. The size of the exhaust is limited to prevent over-ventilating and to avoid excessive depressurization of the house. The principal exhaust fan must provide at least at 50% of the

**Total ventilation capacity**

*(example calculation for a 3 bedroom house)*

| Room | Capacity (l/s) | Capacity (cfm) |
|---|---|---|
| master bedroom | 10 | 21.18 |
| 2 other bedrooms | 10 | 21.18 |
| living room | 5 | 10.59 |
| dining room | 5 | 10.59 |
| kitchen | 5 | 10.59 |
| family room | 5 | 10.59 |
| 3 bathrooms | 15 | 31.77 |
| basement | 10 | 21.18 |
| Total ventilation capacity required | 65 l/s | 137.67 |

total capacity required. If it is a large fan, reducing its air flow must be possible. The concern is that a system run at full capacity could make the house very dry and the heating bills very high, so the occupants might simply turn the ventilation off and forget it.

Ducts must be sized correctly. Measurements of actual installations have found that kitchen and bathroom fans often deliver about half the rated exhaust flows, mainly because of incorrect installation. That is why code tables lay out minimum duct sizes required for each fan. These are to be used if specific recommendations are not provided by the fan manufacturer.

## Supplemental Exhaust

Kitchen and bathroom exhaust fans are required to remove contaminants near their point of origin before they can mix with air from other rooms.

Each kitchen must have an exhaust fan with a minimum capacity of 50 L/s (105 cfm) and each bathroom at least 25 L/s (53 cfm). The total of the supplemental fans must add up to at least the difference between the total ventilation capacity and the capacity of the principal exhaust fan.

Common practice in some parts of the country is to use recirculating range hoods, so this may be a new requirement. Note that recirculating hoods are only partially effective if the charcoal contained in the filter is recharged regularly. Most units have so little charcoal, they can become ineffective at odour removal in a matter of weeks. Not many people are aware of this, and few replenish the filter. The net effect is that most recirculating hoods do little more than make noise!

Downdraft cook tops have fans that vent to the exterior. These have to overcome natural forces, so they are very powerful, and can depressurize houses to unsafe levels. That is why most will require dedicated make-up air.

## Distribution

Fresh outdoor air brought into the house must be distributed to the living areas, especially the bedrooms. This requirement has been introduced into the code because of the mounting evidence of poor air quality in the bedrooms of houses that do not have air ducted circulation.

The outdoor air must be provided to each bedroom and to each floor (including the basement). In houses where there is no storey without a bedroom (e.g., a basement-less bungalow), ventilation air must be supplied to the main living area. This is simple in houses with forced air heating systems because the heating ducts do double duty as ventilating ducts. Houses without forced air heating, such as baseboard or radiant heat, need a system of small ducts to distribute the outdoor air to each bedroom and to each storey without a bedroom.

Outdoor air must be tempered before being circulated through the house. This can be accomplished by using a heat recovery ventilator, a heating element in the incoming air duct or by mixing it with indoor air. However, the latter approach is more complicated as it requires careful design and balance of the airflows between the outdoor air and indoor air ducts. It is too complex to deal prescriptively so where tempering by mixing with indoor air is chosen the system must be designed to meet CSA-F326.

## Ventilation in homes with Forced Air Heating

For the ventilation system tied to a forced air heating system, the heating ducts circulate the outdoor air. The furnace must be wired so that, whenever the principal exhaust fan is running, the furnace runs and fresh outdoor air is brought into the heating system's return air plenum upstream of the connection to the furnace. Minimum duct sizes are specified depending on whether the supply air enters passively or through an auxiliary supply fan.

### 1995 NBC Summary of Ventilation Requirements

**Principal exhaust and supply**
- capacity based on room count
- must be able to ventilate continuously at half the required ventilation capacity
- supply and exhaust must be balanced
- control by centrally located switch
- ventilation air must be distributed to living areas
- supply air must be tempered

**Supplementary exhaust**
- 25 l/s for bathrooms not served by principal exhaust
- 50 l/s in kitchen if not served by principal exhaust
- supplemental exhaust plus principal exhaust fan must equal or exceed total ventilation capacity
- fans must meet sound ratings
- manual controls

**Make-up air**
- must protect against soil gas entry and combustion gas spillage
- must be installed for devices that exhaust more than 75 L/s
- must reduce pressure imbalance to 75 L/s or less
- operate automatically
- incoming air must be tempered



Outdoor air can be tempered before it reaches living areas of the house by mixing it with the return air in the furnace's return air plenum. A 3 m minimum distance between the furnace and the outdoor air supply duct connection is specified to enable a thorough mixing of air before the cold air reaches the furnace heat exchanger. This will avoid condensation of combustion products that could occur resulting in reduced heat exchanger life.

## Ventilation in homes without Air Heating Systems

If there is no forced air heating system or, if it is decided not to use the heating system to distribute the outdoor air, then a dedicated distribution system must be installed. Because the system only handles ventilation air, smaller ducts can be used and the supply fan can be smaller than a normal furnace circulation fan. The supply fan must operate at the same time and rate as the principal exhaust fan to avoid either pressurizing or depressurizing the house.

Fresh air supply grills must be put in the ceiling or high up in the wall, (within 300 mm of the ceiling).

## Protection Against Depressurization

Exhaust fans can cause spillage of combustion products from combustion appliances if the house is depressurized. Appliances vulnerable to pressure-induced spillage are those that draw combustion air from the house, vented through a natural draft chimney. Examples include older gas furnaces and water heaters with a draft hood, oil furnaces with a barometric damper, open fireplaces and wood stoves. Appliances such as gas furnaces and water heaters with induced draft venting systems and the "sealed combustion" oil furnaces are resistant to spillage and do not require make-up air openings.

Most fireplaces are vulnerable to spillage, even those with so-called "airtight" glass doors and outside combustion air intakes, because "airtight" doors are not really airtight. Gas stoves are not required to be vented, but for occupant health and moisture control they should always be vented to the outside. Their operation will not be affected significantly by depressurization of the house so make-up air openings are not required.

A carbon monoxide detector must be installed on or near the ceiling of any room that has a wood burning fireplace or stove, unless the unit has tight fitting doors that close off the firebox from the living area.

If the house includes combustion appliances vented through a chimney, then any exhaust device with a capacity greater than 75 L/s (158 cfm) must be provided with make-up air. The supply fan must be connected to the exhaust fan, so that it works simultaneously. The make-up air has to be tempered to at least 12 °C before being introduced into the living areas. The size of the make-up air fan must be big enough so the net exhaust is reduced to 75 L/s. So for example, a 150 L/s downdraft cook top fan would have to be wired to a 75 L/s supply fan.

## Fan Sound Ratings

Ventilation system fans must be quiet so that building occupants do not turn them off. Fan noise level is expressed in "sones" tested by the Home Ventilating Institute (HVI). The higher the rating, the noisier the fan. The principal exhaust fan must have a maximum rating of 2 sones.

Many kitchen exhaust fans have sone ratings greater than 3.5 so they cannot be used to meet the "for ventilation" capacity requirements. In this case the kitchen exhaust may be met by the principal exhaust fan, if the principal exhaust fan is installed so that it withdraws all of its air from the kitchen.

*Experience in B.C., is that 2.5 sones (the code minimum for the past 5 years) is far too noisy. The B.C. code will be requiring a maximum sound rating of 1.0 sones for continuously operating fans and 1.5 sones for intermittent fans.*

## Ducts

Except for exhaust ducts in kitchens, dedicated ventilation system ducts can be made of combustible materials. (i.e. adequately sized plastic pipe can be used) Exhaust ducts must vent to the outdoors and not into an attic or roof space because venting into such spaces will lead to water condensation within the roof space that will eventually cause serious structural damage.

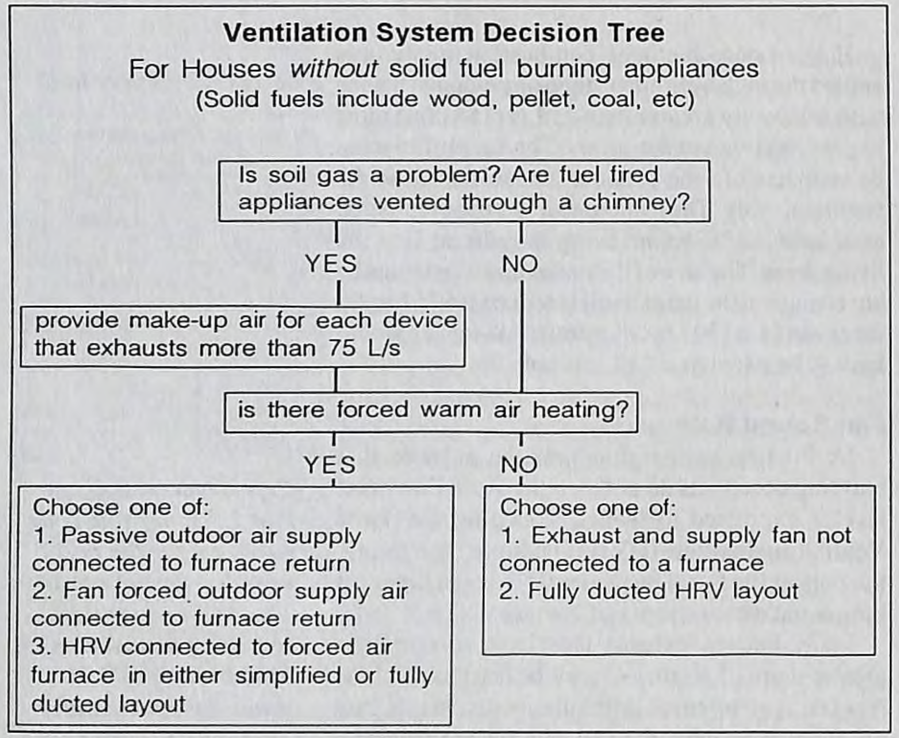
When exhaust ducts pass through unheated spaces, moisture can condense in them, so the ducts must be insulated with waterproof insulation able to withstand occasional wetting, and be airtight to prevent the transfer of moisture into concealed spaces through which they pass. Joints and seams must be sealed.

Supply ducts bringing outdoor air through a heated area (such as fresh air into the return air side of the furnace plenum), must also be insulated.

Kitchen exhaust ducts are subject to build up of grease deposits in them unless they are equipped with grease filters near the intake. The entire duct must be accessible for cleaning if it has no filter.

## Heat Recovery Ventilators

The building code does not require the use of a heat recovery ventilator. However, if an HRV is




installed, manufacturers' installation requirements, including balancing and sizing of air flows must be followed. When operating at the required rate, the two air streams must be balanced within 10% of each other.

The ventilators must be provided with a condensate drain, installed where it will not affect the operation of the system.

### Outdoor Intake and Exhaust Openings

Intake and exhaust duct hoods are subject to rain and snow entry, and also to insects and rodents, so they must be shielded from the weather and be fitted with corrosion-resistant screens.

Air intakes must be clearly labelled, and must be at least 18" above finished grade so in a location where the incoming air will not be contaminated by soil gases, automobile exhaust, oil or gas vents.

Fans designed to operate intermittently must be equipped with back draft dampers.✪

### Resources

*Complying with Residential Ventilation Requirements in the 1995 National Building Code*
CMHC $12.95 Tel: 1-800-668-2642

*Residential Mechanical Ventilation Manual*, HRAI, includes a code guide for specific provinces. This comprehensive manual is aimed at those with a sound understanding of mechanical systems. They also offer code related courses.
HRAI Tel.: 1-800-267-2231
Fax: 905-602-1197

*SHBA Design Sheets: Ventilation Requirements, 1995 National Building Code.* These were prepared for builders to supplement the CMHC code compliance publication. They are free to Saskatchewan Home Builders's Association members. Manitoba HBA is considering using this material. Non-members may purchase copies.
For information:
SHBA, tel.: 306-569-2424, fax: 306-569-9144

## 1998 BC Code Ventilation Requirements

The 1998 BC building code is adopting, with minor modifications, the 1995 NBC except for section 9.32 - the ventilation requirements, which will be unique to BC. This change was made based on the desire to keep incremental costs low, and yet provide minimum standards that are enforceable and yet provide a satisfactory air exchange. They also reflect the fact that most of the construction activity in BC is on the coast, the area with the mildest climate in the country and traditionally the leakiest house construction.

The key elements of the BC code requirements are:

The ventilation capacity is based on number of bedrooms, 30 cfm for a master bedroom, 15 cfm for each additional bedroom to a maximum of 75 cfm. However, there is no requirement for full distribution through the dwelling.

Each bathroom and kitchen must have an exhaust fan with a minimum flow rate (80 cfm for kitchen, 50 cfm for bathroom if intermittent, 20 cfm if continuous).

The principal exhaust fan must either be designed to run continuously, or by adjustable timer to provide a minimum of two 4 hour operating periods per day. In addition, the principal exhaust fan rating is based on air flow at 50 Pa (0.2" WG) external static pressure, and a maximum sound rating of 1.0 sone for continuously operating fans and 1.5 sones for intermittent fans.

Make up air from the exterior must be provided. Passive and active make up air strategies are allowed.

If large exhaust appliances are present, active make up air is required especially in houses with open combustion appliances.

## 1998 Ontario Code Ventilation Requirements

The Ontario building code revised the ventilation standards in the last code revisions, so while the 1998 Ontario building code will be closer to matching the 1995 NBC, section 9.32 - the ventilation requirements, will substantially remain as they have been in the past.

The Ontario code specifies that the ventilation capacity is based on number of bedrooms, 15 L/s (31.8 cfm) for a master bedroom, 7.5 L/s (15 cfm) for each additional bedroom, but if there are more than 4 bedrooms, the ventilation system must be designed.



# Pressure interactions in a house:
## Precautions for Hearth Product Installers

*by David Hill*

In an ongoing quest for improved wintertime comfort, homes today are more airtight.

Besides code requirements, there are two additional market forces at work furthering this trend in multi-family dwellings. Upgraded draft-proofing not only improves fire and smoke protection between units, but is also one of the principal steps to improve suite livability; isolating the occupants from street noises and from adjoining neighbours. In urban areas, air sealing also eliminates the black perimeter carpet 'ghosting' that is becoming a major customer relations liability. In rural and suburban areas, draft-proofing can stop flies and insects from entering a house.

Combustion appliances are widely used for heating, cooking, and decorative purposes. They may be safe and functional, or present potential hazards.

It is important to identify good mechanical equipment and recognize professional installation workmanship, and understand how these affect the home into which we install them. With ongoing changes to construction practice and recent changes in the public attitude toward legal liability, we must broaden our knowledge beyond our own narrow commercial interest.

Three elements we must be cautious of are:

1. Large kitchen down draft exhaust fans
2. Leaky return air duct systems of forced air furnaces
3. Cold chimneys

Ignorance of any of these can expose you to safety liabilities and customer dissatisfaction. The following example may help explain the complex systems operating in a house.

The average new house built in BC today can be thought of as a 100,000 gallon steel oil storage drum. Consider the situation if during the last hunting season some hunters had shot the drum full of holes from all angles, even through the top. The bottom was untouched because it sits directly on a concrete pad. When assessing the repair cost it was determined that all the holes added up to about 1.6 sq. ft.

However, rather than having the holes plugged, the owner decides to put in a floor across the whole tank. The floor is put in half way up between the top and bottom. The "house" has a kitchen exhaust fan, 2 bathroom fans, a clothes dryer, a fireplace and gas forced air furnace. Even without windows and insulation, this is an aerodynamic replica of a new 2000 sq. ft. home built to B.C. code standards. (The typical new prairie house would have a hole about ½ square foot, while in the typical new Ontario house it is about one square foot).

This example can be easily used to explain pressure interactions in a home, although in real life they do not appear so obvious.

### Exhaust Fans

Experience has proven that large kitchen down draft exhaust fans interfere with the safe operation of many hearth products.

It is commonly, but incorrectly, believed that a fan will take from 15 minutes to one hour to affect pressures in the house. Not true! Even before one of these fans has reached full rpm, the house will feel outside pressure pushing inward as the final pressure is reached in about 5 seconds. That pressure depends only on the installed capacity of the fan and the combined leakage area of in the house. House volume will only determine whether the steady state is reached in 2 or 5 seconds.

In my experience, most BC homes are sufficiently leaky that only large exhaust fans become a threat to naturally vented chimneys. The exceptions are very small multi-family dwellings where even small fans may affect the draft in warm chimneys.

### Return Air Leakage

Forced warm air heating systems complicate the situation since a house is compartmentalized into rooms and levels. We normally assume that a furnace will heat the whole house whatever its compartmentalization. We further assume, incorrectly as we have now learned, that the system delivers as much air to each compartment as it withdraws. However, because of its relatively large fan capacity, even a small mismatch between delivered and returned volumes to/from each room will cause one room to become pressurized, and its neighbour to become the opposite. These mechanically induced pressures can easily dwarf building stack action and even the slightly stronger forces of gravity acting on the chimney.

### Cold Chimneys

A chimney can be considered as a 'special' large bore hole penetrating the wall or ceiling. It will be

a warm chimney if its inside, penetrating the house envelope at the ceiling. A cold chimney is mostly outside, penetrating the house envelope through the wall near the bottom of the house. A hole in the ceiling can be considered identical to a hole in the wall until winter begins and the heat is turned on. The moment the interior temperature rises above the outdoor temperature the hole in the ceiling will begin to draft upwards naturally; the strength of the draft increasing as the outdoor temperature falls.

A chimney penetrating the wall at low or even mid-height will very likely reverse and become a make-up air source replacing the air that leaks out through the ceiling. Unfortunately the performance (safety) of a mid-height wall chimney will be determined by whether most of the holes are on the upper or the lower portion of the wall. Only if most of the holes are low and big, will the special mid-height wall hole vent as intended.

### How much depressurization acceptable?

The depressurization limit for a house is normally determined by its weakest chimney. In my experience any chimney penetrating the wall below its ceiling (cold chimney) will be a problem, providing poor or no draft during start-up and sometimes causing complete reversal during tail-out. This situation is aggravated at night when outdoor temperatures fall. Most houses have too many high-level holes that allow heated air to escape which can easily challenge the chimney's draft. The air loss in the upper portion of the structure makes draft performance of the cold chimney (penetrating a low wall) too questionable to count on for safe exhaust of combustion products.

### Conclusion

We must always keep in mind the principle of *the house-as-a-system*. It is no longer enough just to focus on a single product and its specific installation codes. We must learn to foresee any possible interaction before it occurs.

- We will not be able to ensure health and safety if we connect naturally aspirating appliances to an exterior (cold) chimney.
- We will likely never be able to protect ourselves fully (without using absolutely sealed direct vent appliances) against the negative pressures induced by large kitchen exhaust appliances.
- We will never be able to protect ourselves against negative pressures when furnace duct systems are poorly sized/sealed/installed.

To deal with the later two conditions, we must foresee these problems by carefully reading plans for new construction or, in the case of retrofits, looking closely for clues during a walk-through. If other subcontractors install air-handing equipment after our work is complete, and problems then arise, we must have the conviction to place the costs of returning the home to a safe condition squarely on the shoulders of those responsible. ✪

## Polybutylene Plumbing Alert

A North Vancouver lawyer is soliciting business from B.C. homeowners who have polybutylene plumbing pipe installed in their homes. The intent is to start class action suit against the companies that developed and sold the products.

This issue may be blown completely of proportion - but it is a word of caution.

In the USA there was a problem with fittings, but these have not been used for more than 15 years. Apparently, high levels of chlorine can accelerate degradation of the material. In some US locations, chlorine concentrations approach that found in a swimming pool! In the Vancouver area the chlorine concentrations used are too weak to affect the fittings.

In any event, polybutylene piping is no longer manufactured - cross linked polyethylene is used today.

Vancouver area homebuilders, plumbing contractors and suppliers have no knowledge of any problems with polybutylene pipes that would merit a class action lawsuit.

If anyone hears of any such action, keep your HBA association and the TRC informed.

### Utility Deregulation Is No Use to Residential Customers

The American Gas Association says residential electricity customers will see little benefit from deregulation of utilities, but commercial and industrial users will be big winners. Across the USA it predicts that commercial users will see average savings of 26% while residential consumers will see a 10% drop.

As the Canadian energy market starts getting deregulated, we may well expect to see similar moves.



# Construction Alternatives: Rammed Earth

Rammed earth is a traditional building material that has been used for centuries in many parts of the world. Rammed earth uses wooden forms that are placed and secured, damp earth is then loaded into the forms and tamped to total compaction. When the forms are removed, the wall is complete.

The technique requires expertise to recognize soil characteristics and follow appropriate construction details.

**Terra Firma Builders Ltd.**, a Salt Spring Island, custom builder, has been experimenting with rammed earth construction. Since 1993 they have been working with engineers to develop a stabilized earth wall that can withstand a major earthquake. As a result they have created a rammed earth wall with extra strength provided by steel reinforcing and a small amount of cement. These walls have a core of foam insulation. Terra Firma has coined the term SIRE (Stabilized, Insulated Rammed Earth) for this type of wall.

Initially they were drawn to rammed earth construction for environmental reasons. After a while they came to believe that rammed earth might be better than stick framing, especially because of its design flexibility and opportunity for creative interior and exterior finishes.

Compared to stick framing, a SIRE wall may be superior in terms of: indoor air quality, acoustics, energy efficiency, thermal mass, durability, low maintenance, earthquake safety, fire resistance, and resource efficiency.

### Indoor Air Quality

A typical wood-frame wall contains at least forty-six ingredients, including a variety of chemical substances such as siloxanes, solvents, fungicides, volatile organic compounds, urea formaldehyde resin, and urea formaldehyde. Some occur naturally but others are the ingredients of the product manufacturing process.

A stabilized, insulated rammed-earth (SIRE) wall contains six ingredients: earth, water, 10% cement, steel, sealer and foam insulation. The insulation is totally sealed on both sides by the rammed earth, and the wall's surface is coated with a nontoxic sealer to prevent any dusting. Earth itself may contain a variety of constituents, but is a stable, naturally-occurring mix of minerals. Organic matter is kept out of the mix.

### Acoustics

Noise travels both through air and structures. Paying careful attention to reducing air leaks through all the components of a rammed earth building can control airborne sound transmission. A heavy mass wall absorbs considerable sound energy.

Sound transfer through walls is measured in STC numbers (Sound Transmission Class) - the higher the number, the better the soundproofing. A regular, insulated wood-frame wall is rated at STC 40. A "party wall" with staggered studs, insulated and double drywalled on both sides is STC 50. SIRE walls rate over STC 60.

### Energy Efficiency

Terra Firma Builders' SIRE walls have an R-33 value (which can be modified, based on the type and amount of insulation used). In comparison, typical 2x6 wood frame walls have a nominal R20 value. (The effective R-value, when thermal bridging through the framing is considered, is about R17 or less.)

### Thermal Mass

Rammed earth walls retain both heat or cold, keeping a home warm in the winter and cool in the summer.

### Durability

It is possible, even in this age of disposable everything, to build a home that will endure and give comfort for a thousand years. In the Middle East and throughout China there are rammed earth buildings that have stood for several thousand years.

A red brick and mortar wall has a compressive strength of 6-7 MPa (870-1,015 pounds per square inch) and a concrete wall is typically 20 MPa. Engineers' lab tests for the rammed earth walls show compressive strengths averaging 10 Mpa. With extra cement these could be 20 MPa .

### Low Maintenance

Maintenance of a rammed earth wall requires only the periodic application of an invisible, non-toxic, anti-dusting sealer (every 20 years or so). No other maintenance should be needed.

### Earthquake Safety

An engineered rammed earth wall could be expected to experience little or no damage in a mild

*Rammed earth house presently under construction on Saltspring Island, BC.*

earthquake, some repairable damage in a moderate earthquake and would be expected to remain structurally effective while sustaining significant, possibly irreparable, damage in a full code earthquake.

### Fire Resistance

Wood and steel-framed walls have fire-resistance ratings between 45 minutes to one hour, after which time they are no longer load bearing. Rammed earth walls can be expected to have fire ratings of several hours and remain load bearing.

### Resource Efficiency

We now pay an eco-fee for car tires and paint to ameliorate disposal impacts. It is reasonable to think that one day soon we may be paying an eco-fee for difficult to dispose of construction materials, such as asphalt shingles, fibreglass insulation, vinyl siding, plywood, OSB, housewrap, and sheathing paper. Disposing of these materials in an environmentally responsible manner is a huge problem we are leaving for the next generation to face. In Germany, manufacturers already have to take into account the eventual disposal of their products.

Rammed earth uses local soil assembled (rammed) on-site, using lots of local labour and a minimal amount of manufactured materials.

The forms are held together with a cross-tie on top and a strong back shoe pinned into the footings on the bottom. With this system, holes are not cut in the plywood, thus reducing waste.

A typical five-acre treed parcel on Salt Spring Island could provide enough wood for twenty houses. A five-acre pit from which has been used for ramming earth has enough material to build rammed earth walls for more than 5,000 houses (with no loss of precious topsoil). The longevity of a SIRE-walled homes saves tremendously on resource extraction and disposal.

### How much do SIRE walls cost?

A conservative estimate for the cost of a single storey rancher with SIRE walls is approximately 15% more than a similar rancher with conventional stick-frame walls.

### Design Flexibility

Curved walls, rounded archways, arch top windows, and deeply inset window seats are only some designs possible with SIRE walls.

Obviously, this construction approach is not suited for all situations. After all, a 2 foot thick wall can't be fit easily on a 33-foot city lot! Nor is it cheap, so it will not produce affordable housing. However, in the right application, it does offer the opportunity for rather stunning alternatives for custom homes. ☼

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## Durability of Air Tightness Techniques

Air sealing is an important feature of new construction. A building with a leaky envelope will suffer from unnecessarily high energy costs, a less comfortable interior environment and degraded envelope durability resulting from air leakage/moisture deposition problems. However, the question always at the back of one's mind is just how durable are the techniques being used to air seal houses?

Recently, seventeen 8- to 11-year-old houses in Winnipeg for which there was extensive historical data, were retested. The houses were part of the 24 house Flair Homes Energy Demo/CHBA Flair Mark XIV Project. The houses were built by the same builder between 1985 and 1989. They were architecturally similar, but used two different types of air barrier systems: polyethylene and the Airtight Drywall Approach (ADA). Regular airtightness tests were carried out over a three-year period to assess their performance. When the Flair Project was completed in 1989, it provided one of the few long-term assessments of building airtightness.

All of the project houses used stucco on three of the four walls. Although stucco is not intended to serve as part of the air barrier system, its ability to improve the airtightness of wood-frame construction is well established.

Eight of the houses used polyethylene air barrier systems and nine used an early version of the Airtight Drywall Approach (ADA). The latest tests were conducted in 1997.

The tests showed that the average airtightness of the eight polyethylene houses was essentially unchanged. Three of the houses had become leakier, but most of the leakage happened at locations not associated with the polyethylene portions of the air barrier. Locations of major leakage were areas that were both easily accessible for repairs and were not specifically part of the "polyethylene portion" of the house's air barrier system. For example, significant leakage was found at the floor drains, around new duct penetrations or through aged weatherstripping.

No evidence was found to show that polyethylene is unsuited for use as an air barrier material in residential wood-frame construction. The polyethylene used in the houses was manufactured prior to development of the CGSB Can2-51.34 standard, so was not in compliance with current code requirements.

The acoustical sealant used to seal the polyethylene was still accessible at the basement header location in three of the houses. It was noted that in all three cases the sealant was still soft, pliable and appeared to be completely functional after an average of 11 years of use.

The average leakage rate of the nine ADA houses was found to have degraded slightly, with six of the houses somewhat less airtight. All or most of the air leakage occurred at accessible locations which were not part of the ADA portions of the envelope. Major air leakage points included: Leakage around floor drains, and, in one house, through an added uncovered sump pit. In another house, a natural gas furnace was added and a new vent penetration installed through the floor header which was not adequately sealed.

The ADA houses used a relatively early version of that sealing system. Subsequent versions of ADA are believed to have better performance due to the combination of improved materials and better design details. The airtightness results discussed may represent a worst case scenario. ☼

*The Variation of Airtightness of Wood Frame Houses Over An 11 Year Period.* *Paper presented at the Thermal Performance of the Exterior Envelopes of Building VII conference by Gary Proskiw, P. Eng. Winnipeg MB*

## R-2000 Program Renewal

The R-2000 New Home Program is a uniquely successful program that is a partnership between government and industry. It has been in existence for nearly two decades. Initially, it was developed as a response to the energy crises of the 1970's by Natural Resources Canada. Today, it has been recognized that it has had a tremendous effect at upgrading housing products, builder education, construction technology, and reducing the impact of new housing on the environment.

In part, the success of R-2000 has come from the partnership of many interested groups, and because the technical standards are reviewed and updated from time to time. The other strong feature is that although it is a government initiative, it is the Home Builders' Association that administers the program in most areas of the country.

Currently a review of the technical standards is being done. As well, the program's management is undergoing a review as is the marketing and promotion strategies for the program. Anyone who has any suggestions, both positive and negative, on either technical or marketing issues is encouraged to contact their regional R-2000 manager or the R-2000 program directly. ☼

R-2000™

*For information on the R-2000 Program, contact your local program office, or call 1-800-387-2000*

# Technical Research Committee News

**Canadian** Home Builders' Association

## National Building Code Updates

### 1995 NBC Errata

The National Building Code (NBC) is updated every 5 years. The latest edition is officially the 1995 edition. This is the version that is currently being officially implemented in the various jurisdictions across the country. Since the 1995 edition was issued, several errors have been noted, some errata have been issued. Registered owners of copies should now be getting their copies.

Significant Revisions include:

- **Ceiling heights** (Sec. 9.5.3): revised table of allowable room heights.
- **Clearance to gas and electric ranges** (Sec. 9.10.21) This section has been completely rewritten to eliminate the restrictive requirements for clearances around cooking stoves.

### Next Code Revisions

The format of the next edition is undergoing a fundamental review. The intent is to change the code into an objective-based document, rather than a mixture of performance and prescriptive requirements as the present code is. The work is substantial, so the decision has been made that the next edition will not be published in the year 2000, as the present schedule would call for, but rather it will be put off to 2003. This means that the existing code document will remain in force for a longer time. Should there be a need, revisions may be published in the interim.

## Furnace Replacement Issues

Furnaces have to be replaced from time to time. Today's units are significantly different from older models. New blowers, different air flows, air temperatures, and higher efficiencies all mean that operating characteristics may be significantly different.

If you need to replace an older furnace, the job cannot be considered as a simple replacement of the box. The blowers in today's more efficient furnaces are often larger than in the past, so the air flows may not be compatible with the old ducts. Such differences can be significant because when combined with leaky ducts, can create significant pressure imbalances in a house. This can affect the performance of other combustion appliances. It also contributes to staining on floors and other surfaces where there is air leakage between zones at difference pressures.

The Technical Research Committee (TRC) is the industry's forum for the exchange of information on research and development in the housing sector.

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## Farewell John Broniek

For the past eight years, John Broniek has been the technical support person and R-2000 program technical support at the CHBA national office. John has decided that now is an appropriate time to move on. It also helped that he received an offer he couldn't refuse, so effective August 19, John has left CHBA for the greener pastures in the United States, where he will be joining a consulting firm in Pittsburgh involved in the Build America program, a variation of the R-2000 program for the US mass market.

We wish John all the best in his new endeavours.

## Welcome aboard Gary Sharp

John's replacement at CHBA is Gary Sharp. Gary is well known to those who were involved in any way with the Advanced Houses program, as he was Tim Mayo's assistant. Gary brings a diverse background in housing technology to his new job at the CHBA. If you need any technical assistance with R-2000, Envirohome or any other issues, call Gary.

### Oops! The computer gremlins struck again!

In the last issue of Solplan Review the last line of the item on Vapour Diffusion and Air Movement in the Technical Research Committee News got clipped. This could lead to confusion. Fortunately, it was only the last phrase that disappeared into cyberspace. The correct wording of the final paragraph is reproduced here in its totality.

*Proper building envelope design should still provide control from the elements, keeping the outer layers of the cladding dry, reduce vapour transport inwards (e.g., by using heavy building paper, extruded polystyrene insulation, etc.), and control of vapour diffusion outward.*

### Did You know?

Optimizing building design to take full advantage of Passive solar could contribute the equivalent energy output of a 600-MW nuclear plant.

The use of high-performance windows offers more potential for solar use and energy conservation than any other single change in buildings.



# Tackling Global Warming

## Stonyfield Farms' Environmental Cookbook: One Company's Approach

Human activities are changing our planet's climate by emitting heat-trapping greenhouse gases into the atmosphere - including carbon dioxide ($CO_2$), methane, and other gases. Our present use of non-renewable fossil fuels such as oil, gas, and propane is a major contributor of greenhouse gases.

The good news is that climate change due to human activities can be reversed if we take action quickly. Many people and companies are beginning to consider what action they can take. If there were any doubt, consider the words of the CEO of British Petroleum (no raving tree-hugger!):

*The time to consider the policy dimensions of climate change is not when the link between greenhouse gases and climate change is conclusively proven, but when the possibility cannot be discounted and is taken seriously by the society of which we are a part. We in BP have reached that point. It is an important moment for us. A moment when analysis demonstrates the need for action and solutions.*

Reducing our own use of fossil fuels through energy efficiency is a starting point. We can also "offset" our emissions by investments in projects that remove the carbon from the atmosphere or prevent its generation, such as renewable energy, energy efficiency, forest protection and reforestation. Because of global air circulation, the carbon released from fuel combustion in one place can be offset by a renewable energy or forestry project anywhere in the world.

Taking action need not be traumatic or costly. It does, however, require analysis. Sooner or later, we all will have to take action, and it may not be to our liking.

Stonyfield Farms, a New Hampshire yogurt producer, is a case study of what can be done. Two years ago they decided to take action. The use of non renewable fossil fuels and the generation of $CO_2$ were identified as the main issue they should tackle. Goals were set to reduce energy use and to convert to renewable energy. The target was to reduce or offset 100% of the $CO_2$ emissions from their production facilities by the year 2002. The goals were met in 1997.

Stonyfield Farms' $CO_2$ mitigation offers a model that could be used by others. They have published a document that gives a summary of the global climate change issue and lays out an action plan business can follow. Their approach is a six-step process.

### 1: Reduce on-site emissions

Reduce energy use and/or switch to non-carbon emitting renewable fuels. Manufacturers and fabricators can take many actions in this regard for their in house processes. Builders should encourage and feature energy efficient designs.

### 2: Define offsets

Carbon offsets are activities that either remove existing carbon from the atmosphere or prevent additional carbon from being released into the atmosphere. Offsets are 'off-site' activities that do not directly involve a corporation's own emissions. Stonyfield's approach was to support reforestation projects in Oregon. Other projects that achieve similar goals could include solar rural electrification, urban tree planting, etc.

### 3: Determine your "carbon footprint"

A company's total "carbon footprint" is more than just energy use. It must include the emissions resulting from transporting goods, employee travel, solid waste incineration, packaging production, etc.

In the construction and development industry it means evaluating the design impact new developments have on energy use and the environment. The embodied energy content of construction materials has to be considered and take advantage of local materials rather than importing stone and marble from halfway around the globe if local sources are available.

### 4: Calculate emissions

Stonyfield developed a simple worksheet based on the fact that each fuel source has a $CO_2$ factor associated with it. The US national average is that 1 ½ pounds of $CO_2$ are generated for each kWh of electricity (lower in areas with large hydro capacity). Fuel oil and diesel generate 22.4 pounds per US gallon, natural gas 120.6 pounds per 1000 cubic feet, gasoline in cars 19.6 pounds per US gallon, while air travel generates 0.8 pounds per mile.

### 5: Choose an offset project if that is the appropriate route

Offset opportunities can include $CO_2$ emissions reductions, carbon sequestration in vegetation and soils, and emission reductions of other greenhouse gases (such as reducing methane emissions from coal mines, gas pipelines or livestock).

If it takes the equivalent of 20 trees to produce the lumber used in a house, one step a builder may take is to support the planting of at least an equal number of trees in a reforestation project to offset the effect of the trees used.

*The Stonyfield Farms Environmental Cookbook is posted on their website at: www.greenbiz.com/ yogurt.htm*

### 6: Choose an offset partner

Carbon offset programs are a new activity that needs careful evaluation. The quality of the project, monitoring and verification must be considered. Many programs and consultants are now emerging.

With a small financial investment, Stonyfield Farms estimate they will offset approximately 2000 tons of $CO_2$. The offsets will be verified with a strong monitoring system. Although Stonyfield's emissions are relatively small, the collective impact of greenhouse gas abatement by many small - to medium-size firms could be profound.

They have taken to heart the adage that the journey of a thousand miles begins with a single step. ☼

## The Toxic Environment

We all have concerns about our environment, but we do not always appreciate the consequences of our life style of convenience. Many of us are affected by repeated exposure to synthetic products: furnishings, building materials, clothing, household products and food additives.

There is a mistaken idea that environmental illness results from a single exposure to an excessive amount of a toxic substance. However, most individuals are exposed for years to common chemical toxins through their water, air, food, housing, workplace, and cleaning and personal products. A continuing low level exposure can lead to chronic rather than acute symptoms. Most of us do not make the connection.

We are now learning that illnesses with symptoms that mimic asthma, chronic fatigue, arthritis, fibro myalgia, and many others may not actually be those diseases but something else, usually triggered by environmental factors. This growing awareness is stimulating the research and promotion of healthy housing ideas. Responsible builders should become familiar with the products and methods they use in building, to ensure the home environments they build are healthy.

Most books on the subject have been written by people who have first-hand experience with the issue, and deal with the solutions that worked for the authors. A more chilling tale is the trauma sufferers go through before diagnosis is made. The process can be a long and traumatic series of tests. When all test results are negative, the sick person is often assumed to be mentally unbalanced simply because there is no concrete evidence of illness.

In many ways the medical community mirrors what society expects. Rather than rely on the diagnostic ability of the physician, they are programmed to look for a quick fix, a potion or elixir that will provide quick recovery or improvement.

**The Toxic Labyrinth** is a book that documents Heather Millar's story. As a nurse, she saw the situation from an insider's point of view, knowing some of the questions to ask and medical procedures to question. This is an excellent book of one individual's progress through the medical system until diagnosis of environmental illness is established. No products, facilities, or health care professionals are mentioned by name. Rather, one person's experience is presented to show that there is assistance available.

Healthy people find it difficult to appreciate the true impact of environmental illness. We are highlighting this book because it provides a unique point of view. It may be helpful for someone who is suffering but whose doctors are not able to diagnose the illness. It could be someone in your family, an acquaintance, or a customer.

Heather's recovery is progressing and has lead to a new lifestyle. She has established a business to provide resources and assistance for those who are suffering from environmental illness. This includes the development of a text for use in nursing schools (interest has been shown in B.C. and Saskatchewan) and consulting services for individuals. ☼

*The Toxic Labyrinth, a family's Successful Battle Against Environmental Illness* by Myrna Millar and Heather Millar
*Available from the publisher for $17.95 plus S&H & GST:*
*Nico Professional Services Ltd.*
*Tel: 604-733-6530*
*Fax: 604-733-6506*

### Peppers - Secret Pest Repellent of the Future?

Instead of poison or traps, researchers are trying another weapon to fight pests - the world's hottest chili pepper.

A repellent developed by the New Mexico Tech Research Foundation in Socorro, NM has tapped the power of the red habanero pepper, which is 60 times hotter than its fiery cousin, the jalapeno, and 10 times hotter than cayenne.

The spicy ingredient is being mixed into caulks, paints, glues and rubber-coating materials, and any creature, mammal or mollusk, unfortunate enough to take a nibble will get a sizzling surprise. ☼



## Light Pipes

Skylights are used to bring daylight into dark interior areas of a building. The darker the area, or the further indoors, the greater the tendency to use large skylights. Although skylights bring lots of light, they also lose much heat in winter and overheat homes in summer. Some mechanical contractors in Vancouver (an area with no significant cooling loads) insist on air conditioning if they see large skylights in a house. They know that over heating will be a problem.

An alternative has developed recently is marketed as light pipes. They are a cylindrical tube coated on the interior with a highly reflective surface and capped on the ends by plastic domes or plates. Light pipes in effect are cylindrical skylights that bring natural daylight into areas of buildings that are not accessible to windows. These may not have the aesthetic properties of large skylights. However, they are effective at bringing daylight into dark interior spaces - such as hallways, garages, storage rooms and bathrooms.

Claims have been made by manufacturers about light pipes' effectiveness. Until recently, we only had the manufacturers' word for their performance. Recent performance tests done at Queen's University measured how much light they bring in, their thermal properties, energy savings, solar heat gain, and heat losses. The tests were done on a 13" diameter, 6 foot long light pipe installed in the roof of the engineering building, and tested under natural weather conditions.

Having standardized performance data will allow building and lighting designers to use light pipes with some confidence and allow for the comparison of competing products.

Calculation of the thermal resistance for the light pipe is more complex than for a regular skylight, because of the effect of the attic cavity. Heat is lost not just through the glazing, but also along the length of the pipe to the attic cavity. The light pipe has an average R-value of 1.58. This is comparable with a standard clear double-paned glass skylight, although the total area is quite small compared with a small skylight that might be used otherwise. The energy savings due to light pipes will be significant as the smaller surface means smaller heat losses at night, and smaller heat gains in summer. There will also be an energy saving by not having to use electric lights during daylight hours, especially in windowless areas used regularly.

The daylighting performance of the unit was evaluated by measuring interior and exterior light levels over day-long periods. The interior illumination levels changed with the outdoor light levels. However, it was noted that the maximum daily fluctuation of light levels indoors was not as high as it was outdoors (when clouds covered the sun). This is because the light pipe takes advantage of both direct and indirect daylight. ☼

***Preliminary Evaluation of Cylindrical Skylights: Efforts Toward an Evaluation Standard***
*G.G. McCurdy, S.J. Harrison, R. Cooke*
*Solar Calorimetry Laboratory*
*Queen's University, Kingston, Ontario*
*Paper presented at the Solar Energy Society of Canada annual conference 1997*

### Fibre Cement Siding

Fibre Cement as an exterior wall siding has been used for many years in Europe, Australia and Japan. It is a composite material made of Portland cement, sand, wood fiber, and water processed under high temperature and pressure. The finished product is resistant to rot, fire and insects, and is dimensionally stable. However, it will degrade if it becomes wet and remains wet for long periods. Proper finishing will help achieve the expected service life of the material.

Always follow the paint and the fibre cement manufacturer's instructions for paint preparation and application. Clean the surface thoroughly as a lot of dust is created during panel cutting. Dry the siding completely before applying paint.

Paint the siding within ninety days of installation. Make sure the weather conditions are appropriate for painting.

If fibre cement siding panels, are not pre-primed, then apply a high quality alkaline resistant acrylic primer before the finish coat, which should be a high quality, 100% acrylic latex paint.

Use an acrylic latex-based caulk. ☼

### Duct tape: how reliable is it?

Duct tape may be useful for everything except to seal ducts. A recent story from the Lawrence Berkeley National Laboratory in California suggests that duct tapes have not been tested to see how well they seal metal ducts.

During tests researchers found that duct tape almost always failed, and often quite catastrophically.

Thirty percent or more of the air in ducts is lost through leakage, so it does not get where it is supposed to be directed. This can have serious impacts on house heat loss or gain (in air conditioning conditions) and will affect the pressure balances within a house. As a result, quality mechanical contractors today will try to seal all duct work. However, if the duct tape used doesn't perform, it could well be a wasted effort. ☼

# Energy Answers

*Has anyone summarized rules for building an energy efficient commercial-style building?*

*Rob Dumont*

This is my attempt at some rules for energy efficiency in commercial buildings. The rules are shaped by my experience with doing energy audits on more than 100 commercial buildings, most of which were built in the last 30 years, and most of which are performing less well than they should.

While these rules are targeted at commercial buildings, many of these points also apply to multi family residential buildings.

**1. Tightly integrate the design team.**

In too many commercial buildings, the architect does his or her work, and then in a sequential, rather disconnected process, the structural engineer, the mechanical engineer, the electrical engineer, the interior designer, and the landscape architect do their thing. The problem with this approach is that things often do not fit, they are oversized, spaces are either too large or too small for their intended purposes, etcetera, etcetera. For instance, a common problem I see in energy audits is that the space for duct work is too small, so the mechanical engineer has to use very high velocities in ducts with their very high energy costs to move air around.

A portrait painter can work alone very successfully, but buildings are not portraits!

Concurrent, rather than sequential, design using the assembled knowledge of all the professionals involved is strongly recommended. Initial results from the C-2000 program are reinforcing this important idea.

Another very useful approach is to de-couple the design fees from the capital cost of the building. Human nature being what it is, there is a tendency for designers to oversize equipment when their compensation is based on a percentage of the capital cost of the building and its components.

**2. Carefully select the site and the orientation for the building.**

This is not always possible. However, there are many advantages to orienting the long axis of the building in an east-west direction. With this orientation, the main windows on the building will face either south or north. Controlling solar gains on south windows is much easier than on east or west windows. Surprisingly, this approach is a universal one, working as well in buildings in the tropics as it does in cold Canada.

**3. Use a whole building approach, and not a single component approach, when selecting the items to use in the building.**

For instance, T-12 light fixtures are much cheaper than T-8 light fixtures with electronic ballasts and silver reflectors. However, when you factor in the larger cooling load associated with the T-12s, and the larger electrical service and transformers required, the improved T-8 light fixtures will often have the lower cost when all the building systems including lighting, space cooling and electrical supply as a whole are considered. The 2/3 energy saving you get with the T-8 light fixtures is an added benefit.

**4. Use high, but economically justified, insulation levels.**

Insulation works almost every day of the year for you. It has no moving parts. It provides sound control. It saves energy, and it is relatively cheap.

Unfortunately the new Model National Energy Code for Buildings has levels of insulation that are too low, in spite of the Code's claims of being regionally sensitive to construction costs and fuel prices. For instance, in Saskatchewan, the wall insulation for commercial buildings using natural gas heat need only be R12 according to the code.

A major flaw in the economic assumptions used to develop the code was the assumption that the cost of the heating and cooling equipment would not be affected by the amount of insulation. Unfortunately, the code writers ignored the fact that increased insulation can reduce the cost of the heating plant. In part I blame myself for this major flaw in the development of the code, as I sat on the code writing committee, and should have insisted that a holistic analysis be done. The code writers also used an internal heat generation rate for commercial buildings that is much higher than good practise these days. Both assumptions yield low insulation levels.

**5. Build tight.**

This topic is well understood by advanced designers; it is, however, still not well understood by all designers. A tight envelope protects against heat loss and gain, protects against condensation damage, allows one to use heat recovery on the ventilation, and reduces drafts and unevenly heated spaces. A good performance target is to have the building air leakage less than 0.1 litres/second/square metre of surface area when tested at a pressure difference of 75 pascals.

If you are building a gazebo, don't worry about air tightness. Most other buildings should be tight.



**6. Carefully size, shade, orient, and select windows. Use appropriate R values and shading coefficients.**

As mentioned earlier, the orientation of the windows in a building is very important for energy efficiency. Windows provide light, heat (wanted or unwanted), coolth, a visual connection with outdoors, and ventilation if operable. Excellent windows with low-e coatings, argon and krypton gas fills, low conductivity spacer bars, and spectrally selective glass are now available. Techniques such as light shelves can further improve the performance of windows.

**7. Use appropriate ventilation amounts.**

In many commercial buildings, regardless of size, the greatest energy costs are for lighting and ventilation.

Ensure that the ventilation is distributed through the building; use heat recovery on ventilation air for energy savings and to reduce the size of heating and cooling equipment.

In recent work auditing nursing homes, we found resident room bathroom exhaust ventilation rates varying from 100 cubic feet per minute (cfm) down to 0 cfm. The current ASHRAE recommendation for patient bathrooms is about 25 cfm per bathroom.

When buildings are over-ventilated, energy costs sky-rocket; in addition, the air becomes extremely dry in winter inside the buildings unless expensive and maintenance-prone humidification is added.

Another handy tool for saving energy is to reduce the ventilation rate when the building is unoccupied.

**8. Carefully select heating and cooling equipment to minimize over sizing, optimize efficiency, and minimize distribution energy.**

As a general rule, in commercial buildings move heat and coolth with liquids.

All-air systems in commercial buildings are a poor choice for two reasons: the duct sizes tend to be very large and occupy a large volume; and the energy required to move heat and coolth is much higher with air than with water. Water has a heat transport and storage capacity of 62.4 Btu per cubic foot per degree F; air has a capacity of only 0.018 Btu per cubic foot per degree F (the ratio of these two numbers is 3467 to 1.) Use air ducts only to supply ventilation air. Most commercial buildings use air to cool the buildings, resulting in very high air flow rates, large ductwork, and high energy consumption values.

Radiant cooling panels or individual zone fan coils are much preferred.

**9. Design the lighting system using the following principles. Use natural light, light the tasks rather than the space, have appropriate controls, and use high efficiency light fixtures.**

**10. Carefully design the building energy control system to provide a user-friendly interface; avoid the use of proprietary (non-open) direct digital controls (DDC).**

One great advantages of the old pneumatic control systems used in buildings was the interchangeability of the common parts; a Honeywell 3 to 15 psi controller would operate any manufacturer's valve. In the changeover to digital controls, however, a Tower-of-Babel approach exists with existing buildings, and the building owner is locked into a single supplier.

Insist that an open system (BACNET or LONWORKS) be used, and that the system be user-friendly enough that a custodian can operate it.

**11. Use ambient energy (night cooling, prevailing winds, solar energy) to the building's advantage.**

Economizer cycles (using outside air for cooling) are a good idea, but only if the system has reliable dampers and sensors. Many of the rooftop units that I have seen have inoperable dampers, wasting great quantities of energy.

Solar energy systems include both passive and active types. Passive solar systems can usually be addressed through building orientation and window selection and placement. Active solar systems that should be considered are the air-preheating types such as Solarwall, and solar water heaters, especially where cheap natural gas is not available.

**12. Design for serviceability.**

How many people would buy a house that had the furnace on the roof with no staircase leading to the roof? Yet rooftop furnaces and rooftop make-up air units are regularly found on commercial buildings. Thus custodians often have to climb a ladder in freezing weather to change filters, fan belts, and try to diagnose failed equipment. The designer **never** has to do the very unpleasant work of trying to maintain all that poorly located equipment in bitter weather. It is little wonder that roof top units are generally in the poorest shape of all the mechanical equipment.

Another common place for mechanical equipment is crawl spaces with low headroom.

Yet another favourite mistake of designers is to under-size the boiler room. One building we re-

*(Continued on page 19)*

NRC-CNRC

# An Ideal Mechanical Ventilation System for Houses

*By John Haysom*

Houses require an indoor/outdoor exchange of air to replenish oxygen used by occupants and to remove pollutants generated by breathing, household activities and by building materials and furnishings. For many years, natural air leakage provided this air exchange during winter. Houses built before the 1960s tended to be quite leaky and pressure differences between the inside and outside, caused by wind or temperature difference, were sufficient to provide significant air exchange most of the time. However, even a leaky building envelope does not always guarantee adequate air exchange.

The movement of air requires both a pathway (e.g., a leak) and a pressure difference; thus a leaky house will experience no indoor/outdoor air exchange when there is no pressure difference. This is most likely to occur in spring or fall, when winds are light and there is little or no indoor/outdoor temperature difference that can create a stack effect. However, the leakier the house, the less frequent the periods of inadequate air exchange.

## Recently Built Houses Are Fairly Airtight

Based on a 1989 IRC study of the airtightness of recently constructed houses across Canada, it was concluded that most houses built using normal construction practices are sufficiently airtight that air leakage cannot be relied on to provide the accepted air change rate of 0.3 air changes per hour (ach). This is the rate considered necessary to maintain adequate indoor air quality and to avoid high humidity, surface moulds and interstitial condensation. Thus, to ensure a satisfactory rate of air change at all times throughout the heating season, (that is, to provide a rate that most authorities deem necessary to maintain adequate indoor air quality in normal households), houses today need mechanical ventilation systems.

## An Ideal Mechanical Ventilation System

An ideal mechanical ventilation system is currently not achievable because of technology limitations. However, the characteristics of an "ideal" system can be listed as follows:

**Operate when needed.** The system would operate whenever additional indoor/outdoor air exchange is needed and would do so without occupant intervention.

**Operate only when needed.** Because a mechanical ventilation system has costs associated with it (cost of electricity and cost of heating outdoor air brought in), it should not operate when air exchange is not required. This occurs when there are no occupants in the house, and when there are no activities or processes underway that generate pollutants, and there is sufficient air exchange due to wind or stack effect.

**Provide the needed amount of air exchange.** The ideal system would be able to deliver enough outdoor air to meet the probable maximum needs of the household. It would also be capable of modulating delivery so that it did not deliver more air than required at times of reduced need. A system without this capability is likely to provide excess air most of the time it is operating, resulting in higher energy costs and low humidity. As well, a system that is unresponsive can be annoying, possibly causing occupants to stop using it.

**Distribute outdoor air where needed.** It is not enough that the system change the air in the house as a whole to meet the standard of 0.3 ach. It must also be able to deliver the outdoor air to those rooms where occupants spend most of their time.

**Be quiet.** The system would be quiet enough that occupants would not be tempted to turn it off.

**Not interfere with other systems.** A mechanical ventilation system that interferes with a fuel-fired heating system can create a high negative pressure in the house, spilling the harmful products of combustion into the house rather than sending them up the chimney.

**Not interfere with the building envelope.** The system would not create significant positive pressure in the house since this could drive humid indoor air through the building envelope, resulting in interstitial condensation.

## Demand-Controlled Ventilation

A mechanical ventilation system that embodies the first two characteristics described above is known as a "demand-controlled" system." Such a system would ideally be controlled by an array of sensors — one for humidity and one for every pollutant that the system would have to respond to, including carbon monoxide, carbon dioxide, formaldehyde and volatile organic compounds. The system would bring in outdoor air and/or extract indoor air until the sensors determined that specific pollutants were at, or below, predetermined safe levels. Whenever a sensor detected a pollutant concentration above its safe level, the ventilation system would operate.

An ideal system with a full array of sensors is not attainable because there is insufficient knowledge and information to determine which pollutants need to have sensors that should be monitored, and what the acceptable levels for a particular pollutant are. As well, practical, reliable and economical detectors for all pollutants of concern are not available. ✪

*John Haysom is a senior technical advisor with the Codes and Evaluation Program of NRC's Institute for Research in Construction. This article is drawn from IRC's Construction Technology Update Series, Update No. 14, "Why Houses Need Mechanical Ventilation," by the same author.*





*(Continued from page 17)*

cently audited was set up so that the middle water heater in a bank of three water heaters could only be replaced by disconnecting all the plumbing for an adjacent water heater.

**13. Carefully select building materials to reduce off gassing of volatile organic compounds.**

The solution to pollution is not dilution. The solution to air pollution is source control. Don't put odorous compounds in the building, and you will not have to deal with the related air pollution.

**14. Reduce embodied energy in the building by using materials such as wood frame construction, cellulose insulation, locally produced wood materials where appropriate.**

Many designers shun wood products in commercial buildings, often because they are unfamiliar with the code requirements relating to fire.

**15. Educate tenants regarding office equipment selection and use; sub meter tenant energy use to encourage efficient use.**

It is said that you cannot change human nature; it is also true that you should not structure your incentives to bring out the worst in people. If energy is not charged for, energy will be wasted. By sub metering energy use, especially electrical energy, you provide a periodic feedback statement to the users that encourages wise use. ✪



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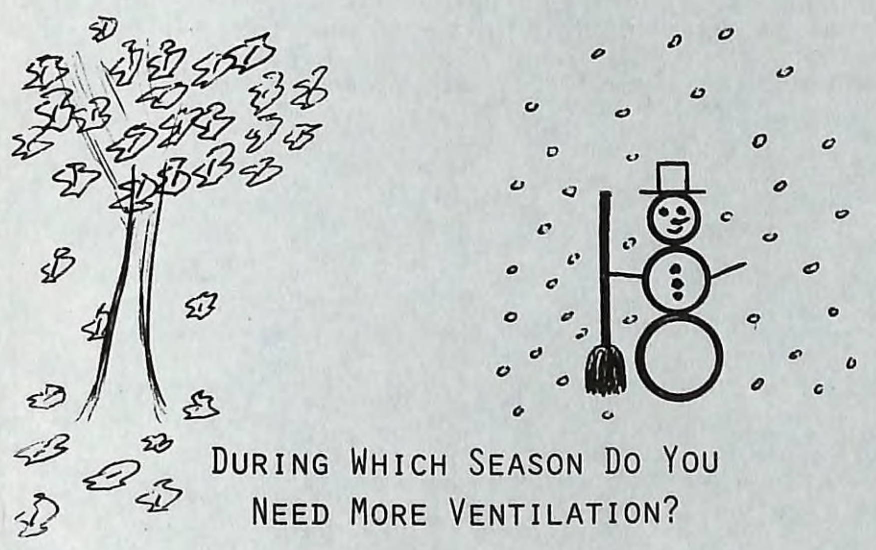


## Coming Events

October 16-17, 1998
NEX '98 North American plumbing, heating & cooling trade show
Toronto, ON
Tel: 416-695-0447
Fax: 416-695-0450
e-mail: ciph@ican.net

October 26-28, 1998
Green Building Challenge '98
Vancouver, BC
Tel: 613-943-2259
Fax: 613-996-9909
http://greenbuilding.ca

October 28-31, 1998
Excellence in Building Conference
1998 EEBA conference
Washington, DC
Tel: 612-851-9940
Fax: 612-851-9507
http://www.eeba.org

November 6, 1998
Housing Issues Conference (CHBA-BC)
Vancouver, BC
Tel: 604-432-7112
Fax: 6504-432-9038

February 14-17, 1999
CHBA National Conference
Regina, SK
Tel: 905-954-0730
Fax: 905-954-0732

April 19-24, 1999
Affordable Comfort
Chicago, IL
Tel: 724-852-3085
Fax: 724-852-3086

May 18-20, 1999
Canada's Energy Efficiency Conference
Ottawa, ON
Tel: 1-800-342-7146
Fax: 613-233-4766

## Stucco Resource Guide

*The Stucco Resource Guide $85.00 plus shipping & handling & GST from the British Columbia Wall and Ceiling Association Tel.: 604-597-7180 Fax: 604-597-7208*

Stucco has been successfully used on residential and commercial building projects throughout North America for hundreds of years. Quality of stucco applications relies on the integrity and qualifications of tradespeople on the job site, as only the basic raw materials are prepared off-site.

Stucco cladding protects the building's structural assembly based on the principle of a "concealed barrier" system. The stucco acts as a primary barrier to the elements, and protects the weather barrier under it. Thus, the real weather protection is offered by the sheathing paper or membrane behind the surface. Moisture that penetrates the stucco, and it inevitably will, is directed away from the structural assembly by the "concealed barrier" composed of properly flashed penetrations, correctly applied building paper, and appropriate metal flashing and trims.

Traditional stucco systems are not designed as a "face sealed" assembly. While attempting to do this with stucco clad buildings has been common, it is not an approach supported by the wall and ceiling industry.

Recent problems have underscored how misunderstood the design principles are, and the inadequate training of all participants in the industry, from design to site workers.

One step taken by the British Columbia Wall and Ceiling Association, a trade association representing the wall and ceiling industry, has been to prepare the Stucco Resource Guide. The Guide was borne out of a need to put into print industry standards for exterior stucco cladding. It is a manual that includes detailed construction drawings, draft specifications (both short and long form) and background information about stucco assemblies.

The detailed drawings are intended to show the various stucco installations and how they interface with the building.